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*Title: Electrodynamic Tethers for Novel LEO Missions*

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The exponential increase of launch system size – and cost – with ΔV makes missions requiring large total impulse cost prohibitive. Northrop Grumman and partners have matured a fundamentally different method for generating propulsion using electrodynamic tethers (EDTs) that escapes the limitations of the rocket equation. With essentially unlimited ΔV, we can perform new classes of missions that are currently unaffordable or unfeasible.

Electrodynamic tether propulsion generates Lorentz force thrust through the interaction between a current driven along a conducting tether and a planetary magnetic field, illustrated Figure 1 below, using the planet itself as reaction mass, rather than an expelled propellant. As a result, this technology provides both high thrust-to-power (as much as 1N/kW) and extremely high specific impulse propulsion (in excess of 100,000s), enabling very large ΔV missions using small, affordable spacecraft systems.

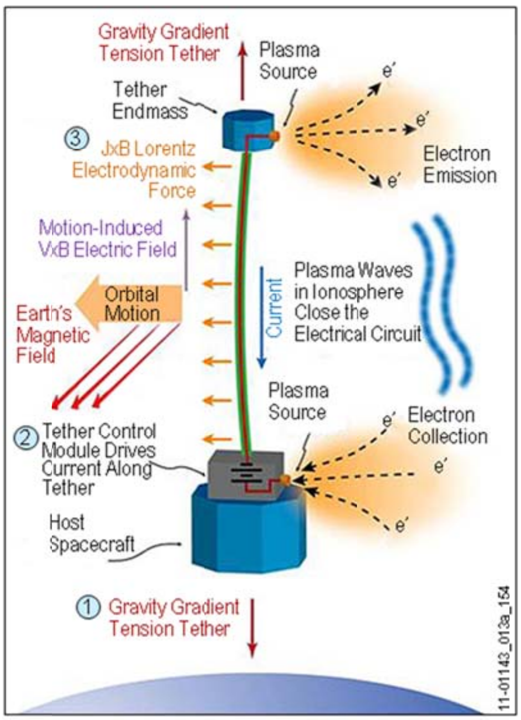


Figure 1: Fundamental physics enable electrodynamic tethers

Today's propulsion systems achieve specific impulses of ~240s for traditional propellants and ~3500s for Hall Effect and ion electric propulsion systems. The EDT escapes the rocket equation limitations by not relying on expelled propellant for propulsion. The electric current through the tether "presses" against the Earth's magnetic field to generate thrust. The ionosphere is used to close the current loop. Since a small consumable helps contact the plasma in the

ionosphere, the specific impulse is finite. Our studies show that EDTs provide the lowest mass system approach for missions with $\Delta V > 1500$ m/s.

The basic physics of electrodynamic tethers have been successfully validated by prior flight experiments, such as the Plasma Motor Generator (PMG) and Tethered Satellite System (TSS) experiments. Northrop Grumman and partners are now ready to demonstrate orbital maneuvering with this technology. Building upon recent investments in prototype hardware development and system design and simulation, the team has constructed a 3-year approach that will validate a system-level, operationally-relevant electrodynamic tether (EDT) propulsion system, preparing it for direct infusion into future missions.

EDTs provide a game-changing capability to undertake new, more ambitious missions such as persistent operations in vLEO for ionospheric science and Earth observation, removal of large numbers of orbital debris, and orbital transfer of propellant and components for exploration missions. EDTs also open a new area of the trade space for traditional missions. EDTs enable propellant-free station keeping and reduce the fuel mass needed for controlled deorbit. When used “in reverse,” EDTs can generate power, providing an alternative source to meet peak demands.

By providing essentially unlimited propulsion from electric power, EDTs extend the spacecraft trade space and enable new missions that are unaffordable with today’s technologies.